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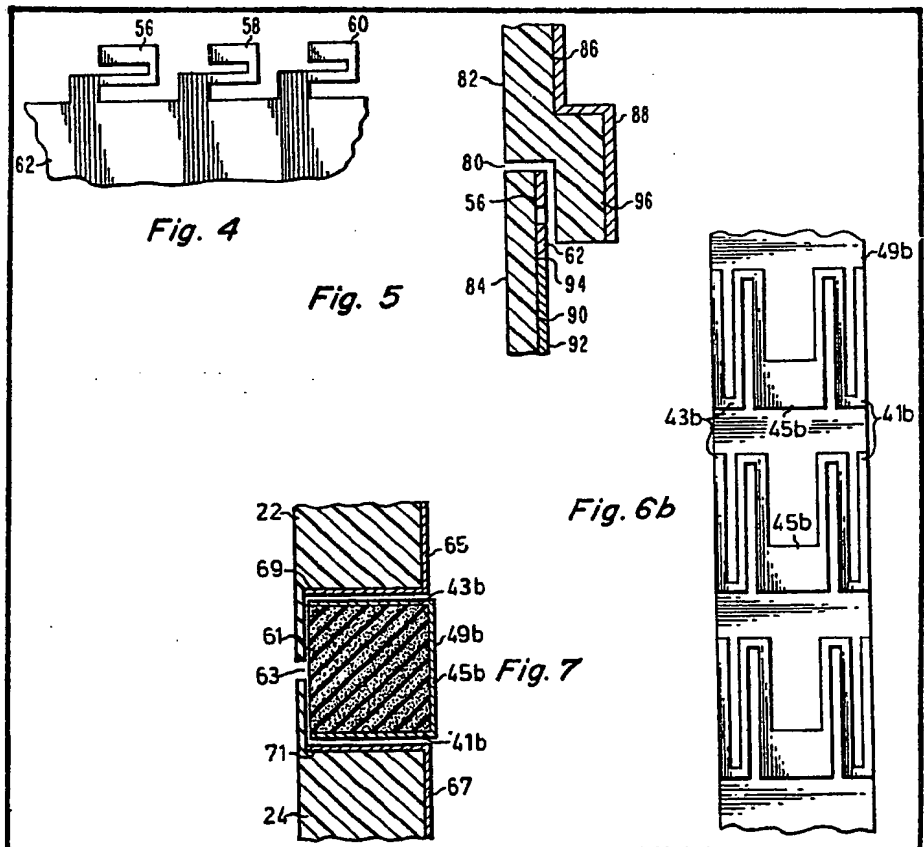
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(54) RF shielding apparatus

(57) A non-contacting RF shield inhibits the flow of energy in a given frequency band through an interface area between two conductive surfaces (88, 92), Fig. 5. A series of stub-like members (56, 58, 60), Fig. 4, are open circuited at one end and connected to a common conductive member (62) on the other end. A portion of one conductive surface (88) is spaced from the stubs such that a plurality of microstrip lines are formed. The open circuits at the one end of the stubs reflect back as low impedance paths between the first surface and the other end of each of the stubs. The common conductive member (62) is

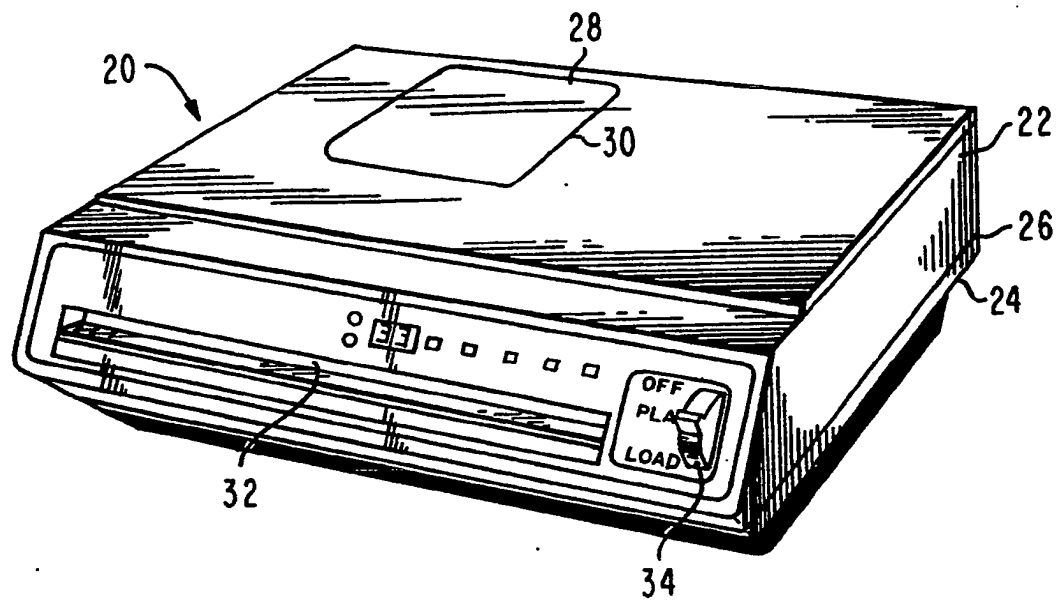
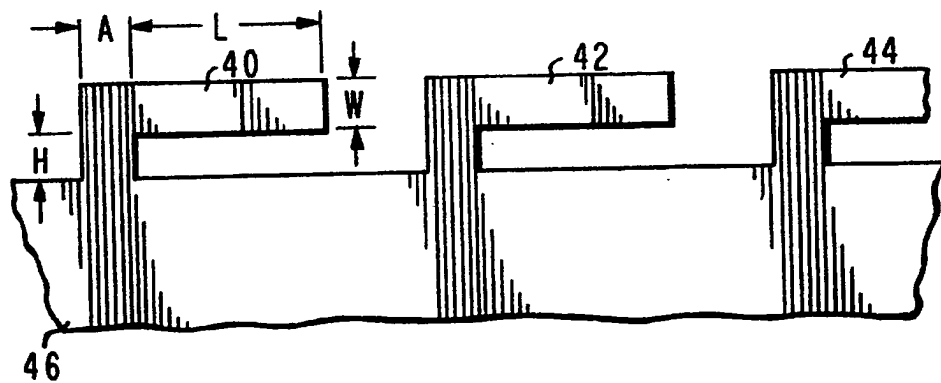
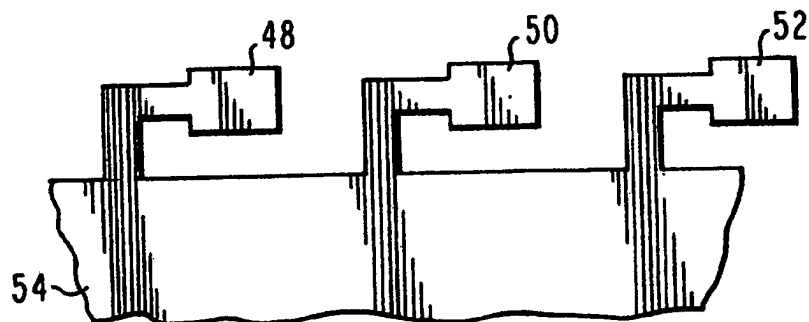
coupled to the other conductive surface (92). This provides a plurality of low impedance paths between the conductive surfaces (88, 92) in the given frequency band without direct physical contact between the conductive surfaces.

In another shield, pairs of conductive stubs (41b, 43b), Fig. 6b, are connected by conductors (45b), the stubs and conductors being supported on a dielectric support (49b) which is wrapped around a resilient core (61), Fig. 7, the support being outermost to form a compact RF gasket. The gasket is placed between two conductive surfaces (69, 71) to provide a low impedance path between them.



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*Fig. 1**Fig. 2**Fig. 3*

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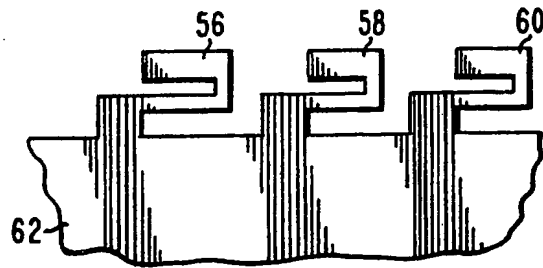


Fig. 4

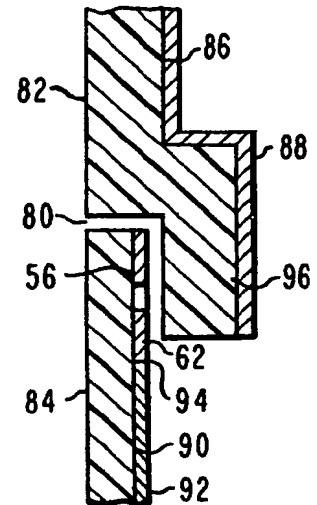


Fig. 5

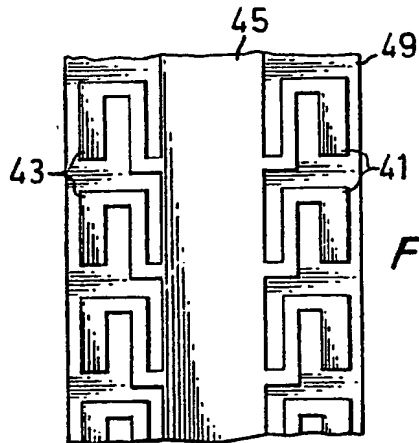


Fig. 6a

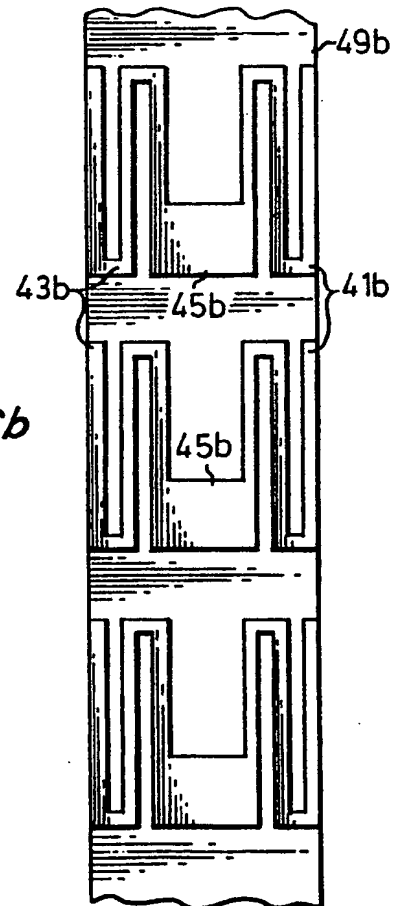


Fig. 6b

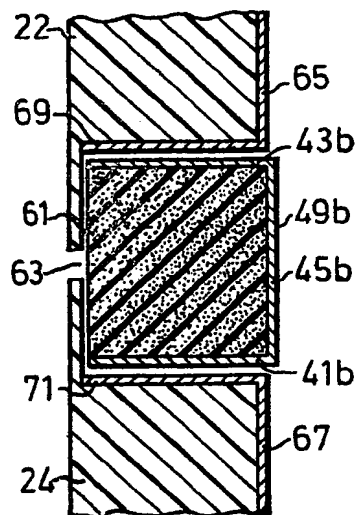


Fig. 7

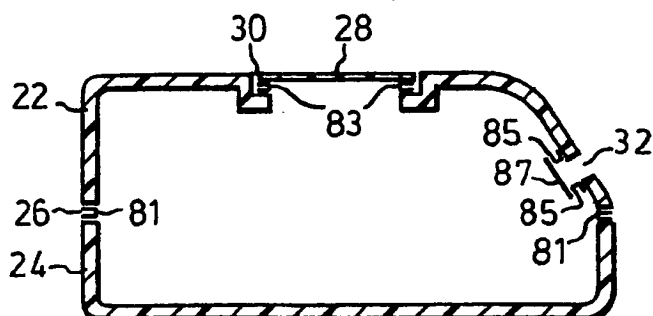


Fig. 8

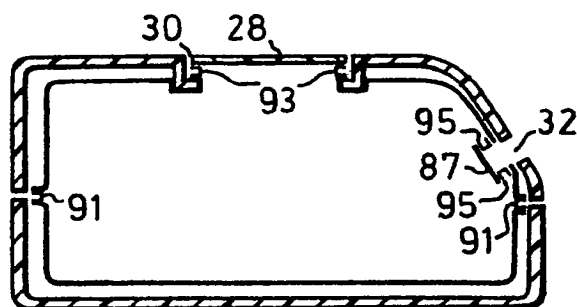


Fig. 9

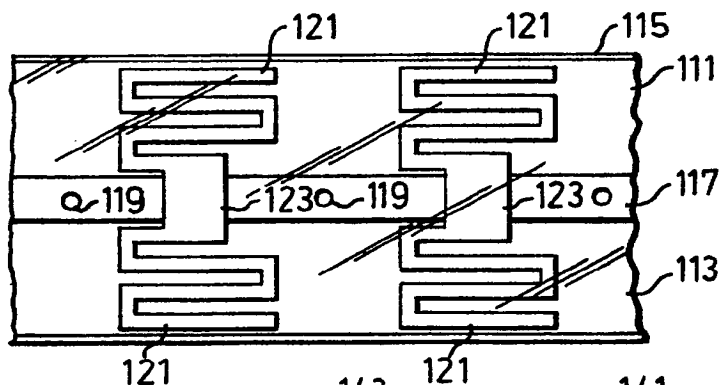


Fig. 10

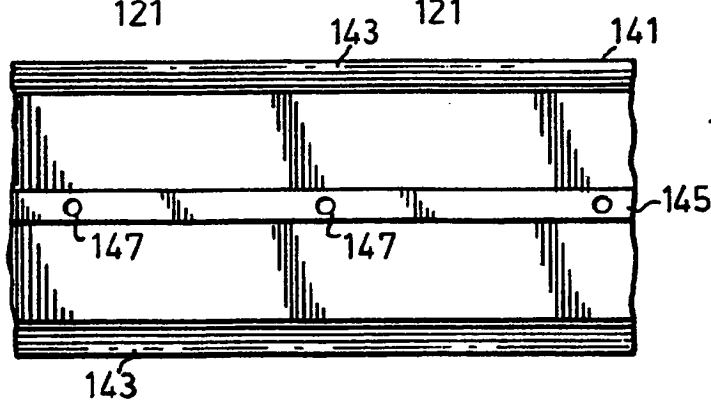


Fig. 11

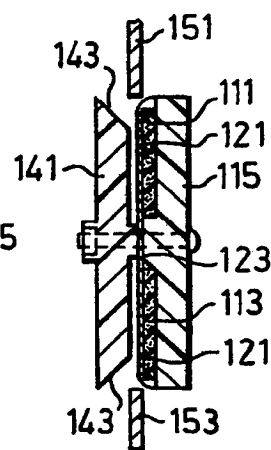


Fig. 12

SPECIFICATION

RF Shielding apparatus

The present invention relates generally to RF shielding apparatus and more particularly to a device for providing improved shielding at the junction between two conductive surfaces without direct electrical contact therebetween.

There are many applications where it is desirable to provide RF shielding either to prevent RF radiation from leaking out, or, by the principle of reciprocity, to prevent interference from external RF radiation. Examples of such applications are radio receivers, microwave ovens, X-ray equipment and certain types of video disc players. In describing the preferred embodiment for practicing the present invention, a video disc player will be used as the example, but, it will be understood that the principles and advantages of the present invention will be applicable to a number of other devices.

In the pickup circuitry for certain capacitive type video disc systems, such as described in U. S. Patent 3,842,194 issued to Clemens, an oscillator is used to drive a tuned circuit, one component of which is the variable capacitance formed between an electrode on a stylus and a conductive property of the playback disc. This oscillator provides a signal at 915 MHz. An example of such pickup circuitry may be found with reference to U. S. Patent 4,080,625 issued to Kawamoto. In the United States this frequency is within the ISM (Industrial, Scientific, Medical) band which has been designated for such equipment. There are standards set for the amount of RF radiation allowed from such equipment to insure that other devices in the area do not experience interference from RF signals generated in the given equipment.

In other countries of the world, notably in Europe, designated frequency bands for certain classes of equipment may not exist. Therefore, to cope with potential RF interference, these countries simply set very stringent requirements for the maximum allowable RF radiation from devices such as video disc players. Thus the problem arises as to the manner in which these stringent requirements can be met.

It is well known in the art that RF radiation may be substantially reduced by enclosing equipment with the potential for radiation (or, by reciprocity, the susceptibility to RF interference) in a conductive enclosure. In the case of a video disc player this may be accomplished by providing an inner metal box surrounded by a decorative outer shell, or, by coating the inside surfaces of the decorative shell with the conductive material.

Despite such an approach, a problem still exists in trying to meet stringent RF radiation standards. The video disc player shell is typically manufactured in two parts, an upper part and a lower part. In addition, a cover or lid is provided in the upper part to provide access to a carriage which houses a replaceable stylus cartridge. It has been found that even with the use of inner metal

boxes or conductive inner surfaces, RF leakage still occurs at the seam separating the upper and lower parts as well as the seam around the cartridge access cover in the upper part.

It is known in the art that leakage (or susceptibility) at such seams can be reduced by providing direct electrically conductive contact between the two conductive surfaces. Typically, this can be achieved through the use of conductive fingers which are often spring loaded to provide good electrical contact. An example of such an arrangement may be found in U. S. Patent No. 2,317,813 issued to Schoenborn. Another approach toward sealing off RF radiation at seams may be found in U. S. Patent No. 2,604,507 issued to Tyson where a metal gasket having pointed edges is used at a seam. In both cases, a reasonable amount of force must be used on the surfaces to be RF shielded to be sure that good electrical contact is obtained.

The problem with such arrangements is that they are costly, they often involve dissimilar metals which can lead to corrosion and the force required to give good contact often results in deformation of the apparatus providing the RF seal. Spring fingers may be bent and metal gaskets may lose their desired shape after repeated assembly and disassembly of the equipment. In addition, consumer access to inner conductive surfaces represents a potential shock hazard.

One aspect of the present invention provides apparatus for reducing RF energy flow at the interface area of two conductive surfaces without a direct electrical contact therebetween. The apparatus comprises a plurality of elongated conductive stub-like members located in the interface area. One end of each of the stubs is connected to a conductive member. The other end of each stub forms an open circuit. A means is provided for spacing at least a portion of one of the conductive surfaces in parallel relationship to the stubs. The stubs and the portion of one of the conductive surfaces form a plurality of microstrip lines. The stubs are dimensioned such that the open circuits are transformed or reflected back at the other end of the stub as a low impedance path in the frequency range of interest. The low impedance paths are then formed between the stubs and the portion of one of the conductive surfaces. A means is provided for coupling the conductive member to the other conductive surface. In this manner a plurality of low impedance paths, in the frequency range of interest, are formed in the interface area between the two conductive surfaces. The "slots" formed by the adjacent low impedance paths are much smaller than a quarter wavelength at the frequency of interest and thus exhibit a very low radiation characteristic.

In accordance with an embodiment of that aspect there is provided an RF gasket having the stub-like members in a folded configuration. As a result of folding these stub-like members it has become possible to increase the packing density

of the low impedance paths. Thus, as a direct result of this, it is possible to increase the number of low impedance paths along a seam and therefore greatly shorten the "slots" created which ultimately results in improved attenuation of energy in the frequency range of interest which would otherwise propagate through the seams or interface area between two conductive surfaces.

In a further embodiment of that aspect, the microstrip lines are formed from conductive material positioned on a thin, elongated dielectric member which is arranged in a substantial U-shape. The gasket in this embodiment may include a resilient member in the inside volume of the U-shaped device.

In the drawing:

Figure 1 is a perspective view of an illustrative video disc player which utilizes the apparatus of the present invention;

Figures 2—4 are examples of stubs which may be used in the practice of the present invention;

Figure 5 is a sketch showing an illustrative embodiment of the present invention at the interface area of two conductive surfaces of the player of Figure 1;

Figures 6a and 6b are sketches of illustrative folded back stubs which are useful in the practice of the present invention;

Figure 7 is a diagram of another illustrative embodiment of the invention at the interface area between two conductive surfaces of the player of Figure 1;

Figure 8 is a cross-section of the player of Figure 1; illustrating one approach to shielding;

Figure 9 shows, in cross-section, a different approach to shielding the player of Figure 1; and

Figures 10—12 show an illustrative embodiment of an RF gasket in accordance with the present invention.

Referring now to Figure 1, video disc player 20 comprises an upper portion 22 and a lower portion 24. The inner surfaces of both the upper and lower portions of the player can be sprayed with an acrylic paint having metal particles so as to create a substantially enclosed conductive housing for the player electronics which includes an oscillator providing a signal at 915 MHz. The upper and lower portions 22 and 24 are joined at the seam 26 which goes all the way around the player. In the alternative, there can be a conductive box inside of the decorative shell of player 20 which would have corresponding seams and openings.

Also shown in Figure 1 is the cartridge access cover or lid 28. When cover 28 is raised or removed, a carriage is exposed which carries the replaceable stylus cartridge. In a player where there is concern about RF radiation, the cover 28 has at least its inner surface made conductive as by the use of conductive paint or, in the alternative there would be a corresponding cover in the enclosed conductive box. The seam 30 represents the interface between the top of portion 22 and the cover 28.

The player 20 also includes an opening 32

which is provided so that a caddy enclosing a record may be inserted into the player to load a record. When the record is loaded and the function lever 34 is moved from the load position to the play position, a door (not shown) inside of the player is moved to close off the opening 32. It is desirable to provide some special apparatus in addition to the door in the area of opening 32 for purposes of RF shielding.

The benefits and advantages of the present invention will be discussed in connection with the seams 26 and 30 shown in Figure 1. Again, one benefit of the present invention is the ability to provide a plurality of substantially short circuits at a given frequency, e.g. 915 MHz, around seams 26 and 30 without direct physical contact being made between the two conductive surfaces of interest. In actual practice of the invention, the short circuits, or, at least low impedance paths, are effective over a band of frequencies centered about 915 MHz.

Figures 2—4 show a variety of stub configurations which may be used in the practice of the present invention. In Figure 2, a series of stubs 40, 42, 44 are shown. Each stub is made from a thin copper conductor and the dimensions of A, H and W are each one-eighth of an inch (about 3 mm) and dimension L is two inches (about 5 mm). One end of each of the stub elements is connected to a common conductive member 46, while the other end of each stub is open circuited. Consider now another conductive surface lying in a plane parallel to the conductive member 46 and stubs 40, 42 and 44. Further consider a dielectric such as polystyrene about one-eighth of an inch (3 mm) thick separating the structure of Figure 2 from the parallel conductive surface. Such a composite structure may be thought of as a plurality of microstrip lines with the other conductive surface forming the ground plane. If the length L is selected such that it is approximately a quarter wavelength at 915 MHz taking into consideration the dielectric constant of the separator, then the open circuit at the far end of each stub will be transformed or reflected back at the near end as a short circuit between the stub and the other conductive surface at the frequency of interest and indeed will be a low impedance path across a band of frequencies such as 900—930 MHz.

Thus, the structure of Figure 2 when combined with a ground plane and dielectric separator will form a plurality of low impedance paths between the near end of the stub and the ground plane in the frequency band of interest.

Figure 3 shows another configuration for the stubs wherein the stub path dimensions are changed. This makes it possible to reduce the stub to stub distance so that a greater number of stubs may be used in connection with a given seam between two conductive surfaces. The stubs 48, 50 and 52 comprise first portions extending from the common conductive member 54, a second portion extending at a right angle from the first portion and a third portion of a

greater width than the second portion extending from the second portion and terminating in an open circuit.

Figure 4 shows stubs 56, 58 and 60 where not only the stub path dimensions are changed but the stub is folded back on itself. This technique permits even greater numbers of stubs to be used without touching one another and without introducing adverse interactions while still providing the desired low impedance paths. Stubs 56, 58 and 60 comprise a first portion extending from common conductive member 62, a second portion at a right angle relative to the first portion, a third portion parallel to the second portion and a fourth portion connecting the second and third portions.

In Figures 2—4 the vertical portions of the stubs extending from the common conductors 46, 54 and 62 provide some inductive loading. In actual practice it may be desirable to shorten the length of the stub to slightly less than a quarter wavelength at the frequency of interest so that the stubs are slightly capacitive to balance out the inductive loading.

It will now be evident that many modifications of the various stub parameters and the configuration as a whole may be made while practicing the present invention.

Turning now to Figure 5, a section of an interface area 80 is shown. This area can be a portion of the seam 26 or the seam 30 in Figure 1. Assume that area 80 is a portion of seam 26. Surface 82 is then representative of the outer surface of the upper portion 22 of the player 20. Surface 84 is representative of the outer surface of the lower portion 24 of the player 20. The upper and lower portions are molded from a material such as polystyrene. The inner surface 86 of the upper portion is coated with a metalized conductive paint to form a conductive surface 88 which extends down to the lower end of the upper portion. Similarly, the inner surface 90 of the lower portion is coated with a metalized conductive paint to form conductive surface 92. It is desired to generate low impedance paths between surface 88 and surface 92 without making a direct physical contact between the conductive surfaces.

To accomplish the desired goal, the arrangement of Figure 4 (for example) is placed on the inner surface 90 of the lower portion near the interface area. It will be understood that there are a plurality of stubs such as 56 going all the way around the seam 26. The common conductive member 62 is electrically connected at 94 to the conductive surface 92. This connection may be a direct physical connection or an electrical low impedance in the frequency band of interest. That is, the microstrip technique described above can be used to form a low impedance connection between member 62 and surface 92.

The overlap extension 96 of the upper portion provides the dielectric (polystyrene) separator between the stub elements such as 56 and the

conductive surface 88. Extension 96 provides a spaced parallel relationship between the plurality of stubs like 56 and the conductive surface 88.

The surface 88 acts as the ground plane which taken with the stubs such as 56 creates a plurality of microstrip lines. Each microstrip line transforms the open circuit at one end to a low impedance path in the vicinity of the common conductive member 62. The common conductive member 62 is electrically connected to the conductive surface 92. Thus the arrangement of Figure 5 provides a plurality of low impedance paths between surface 88, and surface 92 without any direct electrical connection therebetween. This arrangement effectively seals off the interface area 80 in the seam 26 to reduce the radiation of RF energy in the frequency band of interest from the interface area. By reciprocity, the arrangement reduces the possibility of outside RF energy in the band of interest from entering the player 20 through the seam 26.

Figure 6a shows one configuration for forming a first and second plurality of stubs 41 and 43. Stubs 41 and 43 are flat, elongated conductive members, each of which have one end forming an open circuit and have the other end connected to a common conductive member 45. Conductors 41, 43 and 45 are positioned on a thin, elongated dielectric member 49.

The composite structure shown in Figure 6a may be readily produced using photo etching techniques. Copper is first joined to the dielectric which may be a plastic strip such as Mylar about three-eighths of an inch wide (about 9.4 mm) and approximately 0.001 inches in thickness (about 0.025 mm). A photo resist is then used to cover the copper pattern which is to remain. The structure is then exposed to remove the unwanted portions of the copper conductor and, after washing, the composite structure of Figure 6a is left. The stubs 41 and 43 are symmetrically disposed about an axis along the center line of member 45 for ease of manufacture.

The stubs 41 and 43 are dimensioned to optimize the number of stubs along each side of common conductive connecting member 45 and the RF characteristics of the eventual microstrip lines. For example, the width of the stub section extending perpendicularly from conductor 45, and the second section parallel to the long edge of 45, and the third section perpendicular to the second are all of equal width to provide one characteristic impedance while the fourth connected section has a greater width than the first three to provide another characteristic impedance.

Consider now an infinite ground plane being placed behind the composite structure of Figure 6a such that the Mylar (R.T.M) dielectric acts as a spacer between the conductors 41, 43 and 45 and the ground plane. The dimensions of the stubs are such that in the frequency range of interest, say 900 MHz to 930 MHz, there is a frequency, e.g., 915 MHz where the open circuits at the end of the stubs reflect back or are transformed as short circuits or low impedance

paths between the ground plane and the ends of the stubs in the vicinity of the connection to conductor 45. Typically, the overall electrical length of the stubs would be about a quarter wavelength from end to end at 915 MHz to produce this transformation. Electrically the stub length could be any odd multiple of a quarter wavelength at the center frequency. However, the longer the stub becomes, the less effective and more narrow band it would become. In actual practice this length may be shortened so that the individual microstrip lines are slightly capacitive to balance out any tendency toward inductive loading at the junction of the stubs and the conductor 45.

Figure 6b shows another embodiment of the composite stub structure for the video disc player application. Here, each of the stubs 41b and 43b are of equal width and equal length. In addition stubs 41b and 43b have been folded back to form three main elongated sections from the open circuited end to the conductive member 45b. This arrangement permits even tighter packing of stubs compared to Figure 6a so that even more low impedance paths per unit length are created.

Note, in Figure 6b, that the conductive members 45b are separated from one another on the Mylar dielectric strip. The inter-stub space may now be used for positioning fasteners, or the like for providing mechanical connection of the two conductive surfaces forming the seam, or, the inter-stub area can be used for posts to position the gasket along the seam.

In the case of Figure 6b, good results have been achieved using 0.001 inch (0.025 mm) thick Mylar with approximately 0.0007 inch (0.0175 mm) thick copper conductors. The copper stub paths are 0.020 inches (0.5 mm) wide with 0.020 inch (0.5 mm) spacing between the elongated sections. The longest dimension of one stub section is about 0.75 inches (3.75 mm) and the stub to stub spacing is about 0.50 inches (12.5 mm).

Each of the conductive members 45b which joins corresponding ones of the stubs 41b and 43b forms a low impedance path therebetween in the frequency range of interest.

The composite structure of Figure 6b is then folded to form a substantial U-like shape as shown in Figure 7. A resilient member 61 is placed in the central volume of the U-shape. The elongated resilient member 61 may be formed from a material such as flame retardant neoprene foam. The composite structure comprising the dielectric 49b and the conductors 41b, 43b, and 45b are fixed to the resilient member 61 with an adhesive with the conductors 41b and 43b and 45b on the inside of the U-shape and the dielectric on the outside of the U-shape.

This structure is now brought into the interface area 63 between the upper portion 22 and the lower portion 24 of the player of Figure 1. Portions 22 and 24 are formed from a material such as noryl (R.T.M.) and have their inner surfaces covered with a conductive material to

form conductive surfaces 65, 69 and 67, 71 respectively. The RF gasket device is in place all the way around the seam 26 except in the corners. The present gasket allows slots in the seams shorter than an eighth of a wavelength (1.6 inches (40 mm) at 915 MHz). Thus, only the long straight edges require gasketing.

When the upper portion 22 of the player 20 is placed on the lower portion 24 the resiliency of member 61 permits the gasket to fill the interface area despite minor variations in the gap spacing between the lips or ledges at 69 and 71. The dielectric 49 provides the spacing between the stubs 43b and the conductive surface on the inside surface of lip 69. The conductive surface on the inside of lip 69 acts as a ground plane, and, in the frequency range of interest, the open circuits of the microstrip lines provided by stubs 43b are transformed into low impedance paths between the stubs 43b and the ground plane at 69 in the vicinity of conductor 45b.

Similarly, the conductive surface on the inside of lip 71 acts as the ground plane for stubs 41b and, in the frequency range of interest, low impedance paths are provided between the stubs 41b and the ground plane at 71 in the vicinity of conductor 45b.

Thus, since conductor 45b joins the stubs 41b and 43b, the arrangement of the RF gasket in Figure 7 is effective to provide a plurality of low impedance paths in the frequency range of interest, from conductive surface 65 to conductive surface 67 without a direct electrical contact between the two surfaces. These low impedance paths going all the way around the seam 26 have been found to be quite effective in reducing the flow of energy through the interface area of seams such as 26. This results from the fact that the low impedance paths create slots between paths which are short in the frequency range of interest and thus do not allow much leakage or radiation through the slots.

In the embodiment under consideration, the overall gasket has approximately a square cross section of one-eighth of an inch (3.125 mm) on a side. This cross section could have any shape depending upon the application and manufacturing technique used to make the gasket. The length of the gasket is determined by the length of the seam to be sealed off. Dimensions of this nature makes the gasket relatively easy to construct with known techniques while, at the same time, being small enough to be used in applications such as the one under consideration without requiring unusual tooling operations on the player outer shell.

Figure 8 shows the player 20 of Figure 1 where the RF gasket is used in three locations. A gasket 81 is used around the seam 26 as discussed before. In addition, a gasket 83 is used at the seam 30 on the top of the player and a gasket 85 is used along the top and bottom edges of the metal door 87 which is the caddy access door. Gasketing is not required on the short end sections of the door 87 since this dimension

which is about 0.75 inches (18.75 mm) will allow only negligible radiation. Now it will be seen that the major seams of the player which might otherwise permit RF energy flow in the frequency range of interest have been effectively closed off with many low impedance paths between adjacent conductive surfaces.

Figure 9 shows the video disc player 20 wherein a conductive inner box is used for RF shielding purposes. In this configuration RF gasket 91 seals off the upper and lower sections of the conductive box. In addition gasket 93 seals off the interface area between the carriage access lid 28 and a portion of the conductive box near the seam 30 and gasket 95 seals off the seam along the aforementioned edges of door 87 and a portion of the conductive inner box near opening 32.

A preferred gasket for use with a player having an enclosed conductive box such as that shown in Figure 9, but, having generally straight edges around the various seams is shown in Figures 10—12.

In Figure 10, neoprene strips 111 and 113 are placed along the bottom half of a gasket housing 115. The gasket housing bottom includes a raised step 117 having through holes 119 periodically positioned along the length of the step 117. An elongated strip of one mil (0.025 mm) Mylar having a plurality of stub pairs 121 connected by common conductive members 123 is positioned over the housing bottom 115. In this configuration, the stubs 121 and common connectors 123 are formed from one-half ounce copper and may be formed through known etching techniques. The common conductor members 123 are about 0.25 inches (6.25 mm) wide. The folded back stubs are 0.010 inches (0.25 mm) wide and occupy an area 0.375 inches (9.375 mm) wide and 0.090 inches (2.25 mm) above the members 123. The stub-to-stub spacing of the upper stubs is 0.75 inches (18.75 mm) from center to center. The copper side touches the neoprene and the Mylar is facing up.

In other arrangements, common conductive member 123 can be a continuous strip as shown in Figure 6 if desired from a mechanical construction point of view.

Note in this configuration there is a first plurality of stubs (upper ones) and a second plurality of stubs (lower ones). The upper stubs will form low impedance paths to one portion of a conductive member of the enclosed conductive box, say the upper half of the box and the lower stubs will form a low impedance path to another portion of a conductive member of the enclosed conductive box, say the lower half of the box. The common conductive members 123 form the low impedance path between the upper stubs and the lower stubs. By separating the stub pairs (upper and lower) as shown, it is possible to locate the holes 119 as shown for mechanical purposes.

Figure 11 shows the top half of the gasket housing 141. It is made from a plastic material and includes tapers 143, a step 145 and through holes 147 corresponding to holes 119 in the

bottom half.

Figure 12 shows the two halves of the RF gasket assembled. Fasteners are placed through the corresponding holes to form an elongated gasket strip. The gasket strip is then placed along the seam by inserting the upper portion of the conductive box, represented by 151, into the upper part of the gasket. The lower portion of the conductive box, represented by 153, is inserted in the lower part of the gasket.

The Mylar strip has the copper side facing the neoprene 111 and the Mylar strip can be secured to the neoprene and bottom half of the gasket using an adhesive. The Mylar strip is brought around the edges of the bottom half of the gasket and may be secured on the sides or back of the gasket with an adhesive. The neoprene is used so that its resiliency will take up any tolerance variations and thus press the Mylar side of the strip against the inserted conductor such as 151. The holes 119 may be eliminated by using other means to fasten 115 and 141 together, such as an adhesive, or ultrasonic welding.

The theory of operation is that radiation will normally be supported along the elongated dimension of seams. By using the gasket as shown in Figure 12, the effect is the same as placing a plurality of short circuits between the upper part 151 and the lower part 153. This in turn has the effect of breaking up the seam into a plurality of short sections bounded by low impedance paths. The short sections do not readily support the propagation of energy in the frequency range of interest.

The general technique described above for breaking up elongated seams into short sections can also be used for the caddy door of Figure 1 with a straight edged enclosed conductive box as described above. In this case, the upper plurality of stubs works with an upper portion of the enclosed conductive box in the caddy door region to form microstrip lines in accordance with the present invention. The lower plurality of stubs works with a lower portion of the enclosed conductive box in the caddy door region to form a second plurality of microstrip lines. The stub pairs are joined by common conductive members as shown in Figure 10. The stub pairs and the respective common conductors are positioned on the caddy door itself. Thus, in this case, the common conductors are longer in the top to bottom dimension. Again, the net effect is to place a plurality of low impedance paths from the top of the caddy door opening to the bottom and these paths break up the elongated dimension of the caddy door opening (when the caddy door is in the closed position during record playback) into a plurality of short sections which will substantially reduce the ability of the caddy door opening to support the propagation of energy in the frequency band of interest.

It has been found experimentally that the RF gasket as shown in Figures 10—12 is relatively broad band, i.e., it provides a reasonable degree of attenuation across a fairly broad band of

frequencies. Thus, it is effective above and below the specific frequency of interest such as 915 MHz.

It will now be evident that the RF shielding apparatus of the present invention has many applications over and above that of video disc players. Such an apparatus may, for example, be useful in closing off the seam around the door of a microwave oven. In fact, the apparatus according to the present invention should be useful around any seam or interface area where there is concern about RF energy flow in a reasonable band of frequencies.

Claims

1. Apparatus for providing electrical shielding in the interface area between two conductive surfaces without direct electrical contact between said conductive surfaces, said shielding being effective to substantially reduce the flow of energy, in a given frequency band, through said interface area, said apparatus comprising:

a plurality of elongated conductive stub-like members adapted for being positioned in said interface area, one end of each of said stubs being directly connected to a conductive member and the other end of each of said stubs forming open circuits;

means adapted for spacing said stub-like members a given distance from at least a portion of one of said conductive surfaces such that said stub members and said portion of said one of said conductive surfaces form a plurality of microstrip lines when said stub-like members are positioned in said interface area;

each of said stubs being dimensioned such that said open circuits are transformed into low impedance paths in said given frequency band, said paths effectively occurring between said portion of said one conductive surface and respective points in the vicinity of said first ends of said stub; and

means adapted for coupling the said conductive member connected to each stub to the other conductive surface.

2. Apparatus according to claim 1 wherein each of said plurality of stub-like members comprises a first conductive section extending from said conductive member and at least a second conductive section extending perpendicularly from said first section.

3. Apparatus according to Claim 1 or 2 wherein each of said plurality of stub-like members has a total length from one end to the other end which is substantially a quarter wavelength long at a frequency in said given band.

4. Apparatus according to Claim 1, 2 or 3 wherein said two conductive surfaces comprise inner surfaces of a box-like device and said interface area comprises a seam separating said inner surfaces.

5. Apparatus according to Claim 1, 2, 3 or 4 wherein the stubs are connected to a common conductive member.

6. Apparatus according to any one of Claim 1 to 4 comprising:

a first plurality of conductive stub-like members adapted for being positioned in proximity to said one conductive surface;

a second plurality of conductive stub-like members adapted for being positioned in proximity to said other conductive surface; and

means for electrically connecting at least one stub-like member of said first plurality to at least one stub-like member of said second plurality;

said first plurality of stub-like members forming a plurality of low impedance paths in a given frequency range between said connecting means and said one of said conductive surfaces when positioned in proximity to said one conductive surface;

said plurality of stub-like members forming a second plurality of low impedance paths in said given frequency range between said connecting means and the other of said conductive surfaces when positioned in proximity to said other conductive surface.

7. Apparatus according to Claim 6 wherein said first and second plurality of stub-like members and said connecting means are formed on an elongated strip of dielectric material.

8. Apparatus according to Claim 7 wherein said first and second plurality of stub-like members and said connecting means are formed from copper and said dielectric strip is formed from Mylar.

9. Apparatus according to Claim 6 wherein said first plurality, said second plurality and said connecting means are formed into a substantial U-shape and wherein a resilient member is positioned within said substantial U-shape.

10. Apparatus according to Claim 9 further comprising a dielectric member covering the outside surface of said substantial U-shape.

11. Apparatus according to Claim 6 wherein each of said stubs in said first and second plurality have a length from one end to the other end approximately equivalent to an odd multiple of a quarter wavelength at a frequency in said given band.

12. Apparatus according to Claim 6 wherein said connecting means comprises a plurality of conductors each one of which provides a low impedance path between at least one stub-like member of said first plurality and at least one stub-like member of said second plurality.

13. Apparatus according to any preceding claim, wherein each stub-like member is folded back at least once between said one end and said other end.

14. Apparatus for providing, within a predetermined frequency band, a low impedance coupling between two conductive surfaces without direct electrical contact between the surfaces whilst providing a high impedance to radiation within said band tending to radiate through the interface between the surfaces, the apparatus comprising a plurality of conductive strips spaced apart in a direction which, in use of

- the apparatus, lies along the interface by less than one quarter of a wavelength of the frequencies within the band, the strips being supported to be spaced from one of the conductive surfaces by a
- 5 preset distance to form transmission lines therewith, one end of each strip being connected to means for providing, within said band, a low impedance coupling to the other of the
- 10 conductive surfaces, the other end of each strip being open circuited, the dimensions of each strip being such that, within said band, said open circuit at said other end is transformed to a short circuit at said one end thereby providing a low impedance path between the surfaces.
- 15 15. Apparatus according to Claim 14, wherein said low impedance coupling means comprises a like plurality of conductive strips similar to the
- 20 said conductive strips connected to respective ones of the said conductive strips, and similarly arranged to form transmission lines with the other of the conductive surfaces.
- 25 16. Apparatus according to Claim 14, wherein the said low impedance coupling means comprises a common conductive member directly connected to the strips.
- 30 17. Apparatus substantially as hereinbefore described with reference to Fig. 2, or to Fig. 3, or to Figs. 4 and 5.
18. Apparatus substantially as hereinbefore described with reference to Fig. 6a.
19. Apparatus substantially as hereinbefore described with reference to Figs. 6b and 7.
20. Apparatus substantially as hereinbefore described with reference to Figs. 10, 11 and 12.

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